Air Quality Monitoring in Additive Manufacturing

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Aim of the Project

1. Conduct a literature review to determine the state of the art in the research area
2. Conduct a review of technologies and methods used in air quality monitoring in additive manufacturing
3. Analysis of industry standards and guidelines for air quality in additive manufacturing
4. Analysis of the problems of air quality monitoring in the presence of powders and fibres in additive manufacturing
5. Development of guidelines for the management of additive manufacturing processes from the perspective of air quality monitoring.

Background

Background of my project is that I have an interest in 3D printing and additive manufacturing in general and was curious about the air quality effects caused by additive manufacturing processes like FDM and powdered based printing processes like those used in medical product production in the case studies I studied I found that in FDM the material that you used made a difference on air pollutants emitted like VOC's and UFP Particulates And what their effect was on the operator from this I researched how indoor air quality monitoring worked and found that it can be done with a few sensors that is linked to a microcontroller like an Arduino which can feed into a BMS system that can control the room ventilation systems.

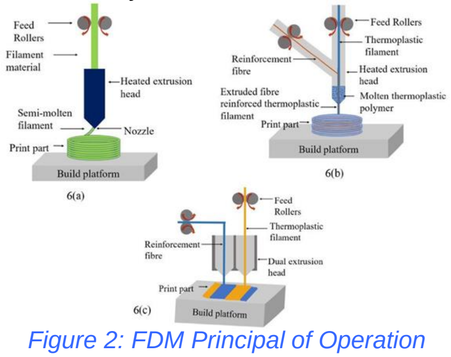

Figure 2: FDM Principal of Operation (Wickramasinghe, et al., 2020)

Case studies

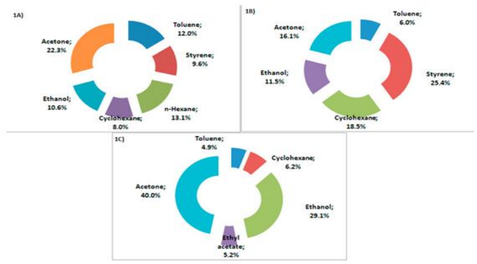

Fig. 1. (a) PLA fingerprint; (b) ABS fingerprint; (c) PET fingerprint

Figure 1: levels of emissions found by (Bravi, et al., 2019).

The case study one it was found that PLA emitted the lowest amount of VOC's making it a safer choice for additive manufacturing whereas ABS emitted the highest amount of VOCs and the VOCs emitted by ABS were styrene and formaldehyde two of the most dangerous organic compounds emitted by FDM filaments with PET being the middle of the two making it a safe and strong filament choice for FDM additive manufacturing.

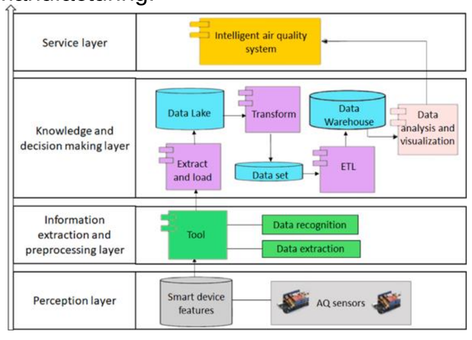

Figure 3: IoT air monitoring systems (Sassi & Fourati, 2022)

Air quality monitoring systems vary in different additive manufacturing areas due to the different compounds and particulate matter that can be found in the air and the required level of humidity will also affect what sensors will be used in the air quality monitoring array, IQ works by using the lights of lasers which the which detect when they are broken by particles of dust and from this it can work out the PPM or parts per million of dust in the air and can use sensors to detect what VOCs and their concentrations are in the air.

Methodology

The project was carried out Via case studies from these case studies I could collect data real time air quality monitoring devices which we use to measure UFPs are particulate matter and VOC's which are omitted from 3D printers during the heating and extruding cycles the case studies found that ventilation can lower these emissions

Results

The case studies found that during FDM printing ABS was the worst for VOC emissions and PLA had the lowest amount but compared 2 ABS PLA had significantly less particulate matter emissions during printing from the case studies it was also seen that powder additive manufacturing processes had significantly more particulate matter emissions compared to VOC emissions but the case study showed that mechanical ventilation with H EPA filters reduced printing emissions down to safe levels recommended by ISO standards it was also found that natural ventilation helps in mitigating emissions from the additive manufacturing processes.

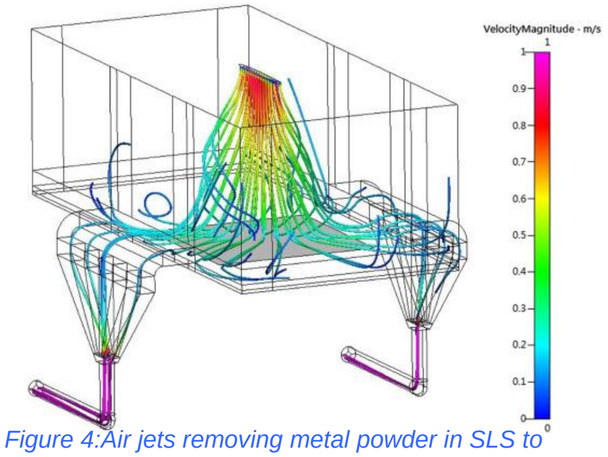

Figure 4:Air jets removing metal powder in SLS to improve on IAQ and recycle otherwise waste (Chen, Tzeng, & Wang, 2020)

The results found in the cases suggested that ventilation should be used whenever additive processes are being used Case study also suggests that whenever powders for as of manufacturing are being used it is best practice to keep The powder from being Overly disturbed and increasing particulate matter in the air.

Conclusion

Ventilation 100-1500m³/h	Average / *limit* ($\mu m^2/cm^3$)	Standard deviation	Maxi. / limit ($\mu m^2/cm^3$)
ON	42.92-compliant	+/- 17.78	101.54- to control
OFF	63.49 – to control	+/- 66.55	469.91-danger

Figure 5: result of the use of ventilation whilst using additive manufacturing machines (Khaki, et al., 2020)

In conclusion it was found the different elements of manufacturing processes like FDM and SLS contributed the most to air pollution with different emission levels depending on what materials were used and the print setup the ventilation setup also accounted for pollution produced by the 3D printer which results in several environmental and health challenges that will need to be addressed to improve safety measures and regulatory oversights in additive manufacturing.

The results had shown the problems poor air quality cause such as to health risks involved we're dealing with powders and carcinogens generated from 3D printing

References

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